IQC: Uncertainty White Paper Status

David Moroni[1], Hampapuram "Rama" Ramapriyan[2], Ge Peng[3]

[1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA

[2]Science Systems and Applications, Inc. & NASA Goddard Space Flight Center

[3]North Carolina State University, Cooperative Institute for Satellite Earth System Studies - (CISESS) at NOAA's National Centers for Environmental Information (NCEI)

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Background and Motivation – Why should we care?

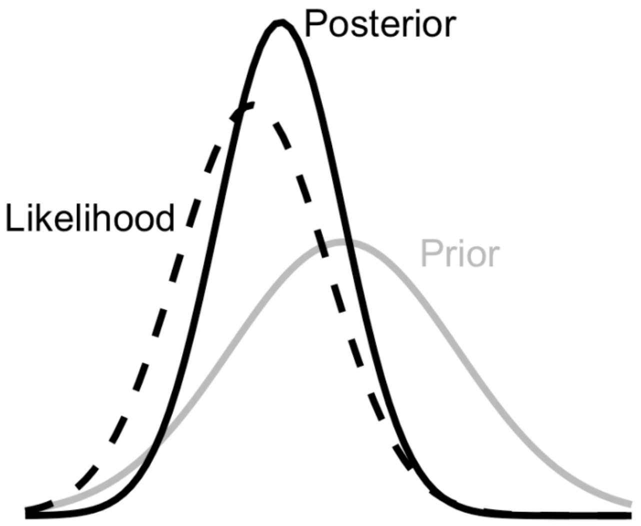
- Uncertainty information provides credibility to data, which leads to credibility of the science, based on such data.
- It can be that unbiased “telephoto lens” into subtleties about data that would otherwise go unnoticed.
- Provides the scientist with discernable information about which dataset is most suitable, in a world where many datasets exist for the same type of observation, based purely on statistics which are agnostic to the results which the dataset(s) may or may not be utilized to support.
- The age of “Big Data” is upon us, but yet many data users (mostly non-experts in numerical analysis) are often left to their own devices as to how to sift through uncertainty information and/or how to derive this information “from scratch”.
- Uncertainty information fundamentally impacts the “science” quality of data, but the availability and packaging of this information can have significant downstream impacts on “product”, “stewardship”, and “service” quality.

White Paper Scope

- Primary focus on “discovery” of the breadth of approaches with regard to Earth science data UQ, UC, and the dissemination/utilization of UQ/UC information by data providers and end users.
- Considers 4 perspectives: Mathematical, Programmatic, Observational, User.
- Will identify both commonalities and differences between perspectives.
- Authors and co-authors represent various aspects of Earth science data informatics, metrology, data science/statistics, remote sensing, in situ, and disciplinary fundamental research.
- Numerical modeling was considered for the sake of use case discussion, but was decided to be left out for the sake of focusing on approaches using observational data.

Mathematical

- Championed by Jonathan Hobbs - JPL
- Considered to be the foundational section of the paper, establishing the key mathematically-based definitions of uncertainty and related constructs such as UQ, UC, mean square error, PDFs, quantiles, confidence intervals, confidence levels, etc…
- Presents directly applicable use cases by which these mathematical definitions are applicable to observational Earth science data, primarily from a remote sensing perspective, but much of which utilizes consistent metrology for a variety of measurement types, including in situ and sub-orbital.



Schematic implementation of Bayes' theorem for a univariate QOI. The prior distribution is combined with information from an observation (via the likelihood) to produce a posterior distribution.

Programmatic

- Championed by Rama – SSAI/NASA GSFC.
- Captures the governmental and intergovernmental approaches, starting with specific US-based agencies and moving into the international arena.
  - Considers US law that drives policy at key agencies, including but not limited to NASA and NOAA.
  - Considers international agreements, such as by the U.N, IPCC, WMO, and CEOS.
  - Considers multi-lateral agreements, statements and policies by EU-sponsored agencies/organizations, such as by: ESA, FIDUCEO, UncertWeb, and MetEOC.

Observational

- Championed by Justin Goldstein – NOAA.
- Discusses the foundational approaches to UQ and UC from an Earth observation perspective, including perspectives from both point-based studies, invariant in space but not in time (e.g., Eulerian Specifications), and those that conduct observations varying in *both* space and time (e.g., Lagrangian Specifications).
- Cal/Val: looks at UQ and UC approaches from a calibration and validation perspective and the role played by “ground truth” data.
- Product Development: examines a variety of approaches and considerations toward making uncertainty information available for common types of observational data products, with a focus on making this information available at the production stage of data.

User

- Championed by Bob Downs – Columbia University.
- Focuses on the ways in which uncertainty information can be effectively or ineffectively consumed, interpreted and ultimately leveraged by the typical data user.
- Provides insights in to methods of communication, dissemination, visualization tools/services, and multi-variate analysis.
- Examples considered include: ISO-19157, UncertML, CO2SYS, and OGC's Testbed-12 innovation program (OGC, 2017).

Next Steps

- Complete by August:
  - Commonalities, differences, conclusions.
  - Re-write the introduction to better align with main sections.
  - Include more graphics/figures.
- Complete by September
  - Prep for white paper publication; consult with Rose Borden to apply improved styling and consistent references/citation styling adhering to AGU standard.

Ideas beyond this publication…

- Draft and publish a shortened “executive summary” paper in a more prominent journal, such as Data Science or EOS.
- Draft a part-2 paper, focusing on recommendations and actionable solutions.

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Co-Author Affiliations

1. Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA
2. Science Systems and Applications, Inc. & NASA Goddard Space Flight Center
3. North Carolina State University (NCSU), Cooperative Institute for Climate and Satellites-North Carolina (CICS-NC) at NOAA’s National Centers for Environmental Information (NCEI), Asheville, NC
4. NASA Goddard Space Flight Center
5. NASA Goddard Space Flight Center and University of Maryland, Baltimore County
6. University of Reading and National Centre for Earth Observation, Reading, UK
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14. University of Oklahoma- Cooperative Institute for Mesoscale Meteorological Studies
15. NOAA’s National Centers for Environmental Information
16. Center for International Earth Science Information Network, Columbia University
17. University of Colorado Boulder
18. Curtin University, Australia